

MINISTRY OF AGRICULTURE AND FISHERIES.

STUDIES CONCERNING
THE HANDLING OF MILK.



LONDON:

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MINISTRY OF AGRICULTURE AND FISHERIES.

STUDIES CONCERNING
THE HANDLING OF MILK

BY
THE STAFF OF
THE NATIONAL INSTITUTE FOR RESEARCH
IN DAIRYING, UNIVERSITY COLLEGE, READING.



LONDON:

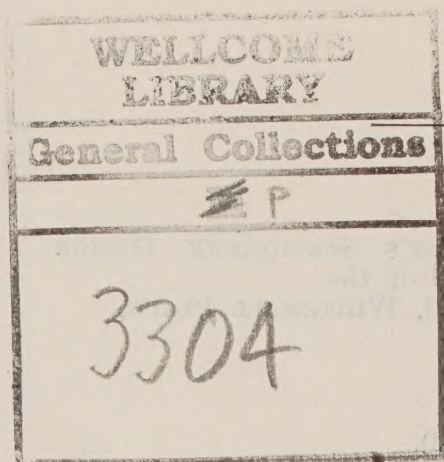
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PREFACE.

The annual expenditure by the State on agricultural research now reaches very considerable dimensions, partly as a result of the provision by the Corn Production Acts (Repeal) Act of the fund of £850,000 for the development of agricultural research and education. A proportion of the annual expenditure (amounting approximately to £100,000) takes the form of annual grants in aid of fundamental and continuing research work carried out at Agricultural Research Institutes, each of which deals with a special subject (soils, plant diseases, fruit growing, dairying, and so on). There are still a few gaps in the scheme of agricultural research, but these are being filled, and the nation may justly claim that it has created an organisation which covers every side of agriculture and has laid the foundations for that complete scientific investigation upon which any great and lasting improvement of agricultural practice must ultimately be based.

A policy which has for its object the increase of facilities for research would be incomplete without arrangements for ensuring that the results of research are made available for farmers. For this purpose a service of specialist advisory officers (entomologists, mycologists, chemists, economists and veterinarians) attached to University Departments of Agriculture and Agricultural Colleges has been established, the country being divided into fourteen provinces for the purpose; and County Councils have appointed agricultural organisers and county agricultural staffs. It is the duty of all these officers to familiarise themselves with the results of research, apply them to local conditions, and bring them home to the best of their ability to farmers in their areas.

Lectures given by University, College, and County lecturers on agricultural subjects to students at Agricultural Colleges, Farm Institutes and audiences of farmers and farm workers aid in the dissemination of new knowledge. Quite recently the Ministry of Agriculture has set on foot, in co-operation with the National Farmers' Union, a scheme by which addresses at meetings of branches of the Farmers' Union are given by the men who are engaged in research work at the different Institutes.

The spoken word has a magic which the book cannot possess, but all things are not meet to be spoken, and the printed word, moreover, can reach those who have no opportunity of hearing lectures. The Ministry has published a large series of leaflets, dealing with every branch of agricultural practice, which are revised frequently to embody the latest results of research; and every month its *Journal* brings to a considerable agricultural

public one or more articles by research workers detailing their methods and results.

Besides the farming community, however, it is necessary also that the wider public should be made aware of the progress of agricultural research; and as much with the object of informing them as the farmer, the Ministry in 1921 directed Mr. V. E. Wilkins to compile a readily intelligible, summary account of practically the whole of the work on which agricultural researchers were then engaged. The resulting book, "Agricultural Research and the Farmer," received a cordial welcome and a ready sale, more than sufficient to encourage the Ministry to proceed with the publication of a series of monographs taking in turn subjects upon which the research worker has something new and valuable to say to the farmer and saying it in greater detail than was possible in Mr. Wilkins' book.

The present monograph, the first of the series, has been compiled by Dr. Stenhouse Williams and the staff of the National Institute for Research in Dairying. This Institute dates back to 1911, for it was on 30th September in that year that the then Board of Agriculture received a memorandum urging the suitability of Reading as a centre for dairying research, and in reply indicated its willingness to make a two-thirds contribution up to £2,500 per annum towards the cost of such an Institute. The first payment authorised by the Ministry was one of £7 on milk churns, milk, sterilising, &c., in connection with an investigation into the effect of ventilated and unventilated churns on the keeping properties of milk in transit. In 1912-13 the Ministry's annual grant was £1,510, an amount which has gradually increased to about £8,000 a year. The Institute, whose work touches vital questions of public health, is supported also by the Ministry of Health, and the Medical Research Council, as well as by the Royal Agricultural Society of England and the dairy industry.

Large sums of money have been raised by the Institute for capital purposes and the Treasury has, since the war, sanctioned capital grants amounting to £32,000 on the condition that equal sums are raised from other sources. With this assistance, and also largely through the munificence of Viscount Elveden, the Institute has been able to provide itself with new buildings and a farm of its own, where its work will continue and develop under the best conditions. Further financial assistance from other than Government sources is, however, still a crying need of the Institute.

The subject chosen for this first monograph is of particular interest at the present time in the light of the Milk and Dairies (Amendment) Act, 1922, and the attention which is now given to the production of clean milk. The book has been written in as simple language as possible, and the use of scientific terms has been reduced to a minimum in order that it may be readily

intelligible to all classes of readers. It should appeal to a wide public—dairy farmers, milk distributors and sellers, medical men—and, it is to be hoped, to some at least of the milk-consuming public, who are not professionally interested in it. Milk is not consumed either in sufficient quantity or in such a condition of cleanliness as to promote, as it might promote, the health and well-being of the people, who cannot afford to be ignorant of how it is produced and distributed, and of how those things might be better done with advantage to producer and consumer alike.

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June, 1924.

PRELIMINARY INVESTIGATIONS.

There comes a stage in any piece of work when it is of interest to review the whole position and consider whence the work arose, what it has done, and whither it is leading.

This stage has now been reached in the work upon the methods of handling milk which has formed a considerable proportion of the investigations which have been carried out at the National Institute for Research in Dairying during the past ten years. The review which is here undertaken should demonstrate that important research work may develop out of work which, in its origin, is not apparently related to it. It should also make clear the great value of the study of the methods of handling milk under the conditions which exist in this country, not only to the whole milk industry, but also to those who are engaged in the preparation of milk products.

The beginnings of this work go back to the days before the foundation of the National Institute for Research in Dairying when Golding¹ who was then at the Midland Agricultural College demonstrated that bacteria which were capable of producing colour changes in media containing tyrosine, which is present in ripe cheese, could be isolated from discoloured Stilton cheese. In this work he was following in the footsteps of Beijerinck² who had previously demonstrated that certain bacteria possessed ferments which, by acting upon tyrosine, could produce colour changes.

The work was still at this stage when the National Institute for Research in Dairying was founded at Reading in 1912. It was clear that this investigation was of considerable interest and that much remained to be done before the problem could be regarded as satisfactorily solved. It was obviously necessary to set in their proper groups any types of organisms which might be responsible for discoloration, to study their sources of origin, that these might, if possible, be eliminated, to find out the conditions under which they could produce colour changes and to satisfy oneself that changes which were produced in the laboratory might also occur in practical cheesemaking.

It is only quite recently that the solution of some of the cheesemaking problems has been obtained, but the importance of this work in demonstrating the necessity for studying the methods of handling milk has long been evident.

Williams,³ and Redman⁴ demonstrated the great variety of types of bacteria which could be found in discoloured cheese. The possibility that some of these types might produce discoloration was also made clear. It was further found that such types were not present in milk as it is found in the cow's udder, since Burri⁵ had investigated the nature of these organisms, and those which produced discoloration were not of similar types to those found in the cow's udder. The discolouring organisms were, therefore, additions to the milk after it had left the cow's

udder, additions which were introduced into the milk at some stage in its handling. When it was further demonstrated^{4 and 3} that these types could be isolated from the milk as it reached the factory, from the water supplies on the farms and that some of them belonged to types which are known to occur in faecal contamination, it became clear that a sanitary survey of the farms supplying the milk to the factory was necessary. This was carried out by Williams, Hoy and Mattick with the help of Mr. T. Talfourd Cumming, A.R.I.B.A., whose assistance made it possible to secure accurate plans of the cowsheds and their relations to water supplies and drainage. The results obtained were gathered together, and these workers, with Mackintosh,⁶ prepared a report showing the very unsatisfactory conditions under which the milk was being produced and the abundant possibilities which existed of dirt contamination of the milk. This report has never been published though it is of the utmost value as a sanitary record of the conditions of milk handling in this country. Its importance to this review lies in the fact that, taken in conjunction with the laboratory work, it revealed the serious damage which dirty milk could cause to the Stilton industry. It is, of course, true that the Stilton industry is a small fraction of the whole cheesemaking industry in this country, though whether it could not be developed may be a question worthy of consideration. None the less this work was one of the guiding posts which ultimately led the staff of the Institute upon an important path, and should be recorded.

A further step was taken during the years 1916-17 when an inquiry into the sources of loss in the whole-milk trade was carried out. Some of the results of that inquiry were published in the *Journal of the Royal Agricultural Society* for 1917,⁷ from which the following quotation is taken:—

“For some time past inquiries have been carried out concerning the losses and sources of loss which occur in the milk and dairy industries. These inquiries were undertaken partly in order to demonstrate the need or otherwise of investigations, partly in order to find out in which directions such investigations, if necessary, might be most profitably undertaken. Many of the inquiries are still incomplete; but the following figures, dealing with milk sent by rail for human consumption, are sufficiently significant to be worthy of consideration.

The figures shown in Table I represent the average annual losses in the milk industries in two widely separated districts.

The first district was in receipt of an annual supply of rail milk of about 90,000,000 gallons. When inquiries were made among the distributors of the milk in the district the following sources of loss were found to exist:

- (1) Milk which arrived sour and unfit for distribution, 1 per cent.
- (2) Loss by splashing, about 3 pints per churn.

(3) Milk which, though not sour, yet required pasteurization before delivery to consumers, 10 per cent.

(4) Irregularity of supply and demand, necessitating the purchase of accommodation milk and the sale of surplus milk. The average loss from this cause amounted to 1*d.* per gallon.

The annual milk supply of the second district amounted to 75,000,000 gallons. In this case no information was given concerning losses 2, 3 and 4, but the loss from sour milk was stated to be 1 to 2 per cent. of the whole. This second milk supply was in a dairying district, and it is possible that some of the losses found in districts which produce milk for human consumption only (*e.g.* irregularity of supply), may be avoided, but it is probable that the loss by splashing, which seems to be general, was suffered. If it be assumed that each churn was full when it was sent out, this loss would amount to 1,654,000 gallons in the course of a year.

If the value of milk be taken at 1*s.* a gallon, then the following losses are found to occur in these two supplies :—

TABLE I.

	Gallons of milk annually.	Value at 1 <i>s.</i> a gallon.
<i>District 1.</i>	90,000,000	£4,500,000
Losses—		£
(1) 1 per cent. sour - - - -	900,000	45,000
(2) 3 pints per churn lost by splashing	1,965,441	98,272
(3) 10 per cent. pasteurized at $\frac{1}{2}$ <i>d.</i> a gallon - - - -	8,713,455	18,153
(4) Irregularity of supply and de- mand necessitating purchase of accommodation milk and sale of surplus at a loss, 1 <i>d.</i> a gallon -		375,000
Total losses - - - -		£536,425

These losses represent a loss of about one-ninth of the monetary value of this supply.

	Gal.	£
<i>District 2.</i>	75,000,000	3,750,000
Losses—		
1-2 per cent. sour, at 1 per cent. -	750,000	37,500

If these figures be considered it is clear that the sources of loss may be divided into two main groups :—(1) those which involve not only financial loss but also the loss of valuable food-stuff, and (2) those which at first sight would appear to be trade losses; none the less, they are of importance to the nation, since their incidence must be considered by the dealer in fixing his price to the consumer, and they must, therefore, tend to increase the cost of milk. The loss due to souring in district 1 amounted to 900,000 gallons, and in district 2 to not less than 750,000

gallons. If it be assumed that there was no loss by splashing in district 2, there remains an annual loss of 1,965,441 gallons of milk in district 1 from this cause.

The losses due to sour milk and waste by splashing when taken together show that of 165,000,000 gallons of milk, not less than 3,615,441 gallons were wasted, representing a loss of about 2 per cent. of the whole supply, and a very serious loss of valuable foodstuff.

The remaining sources of loss comprised that portion of the milk which required to be pasteurized before it could be sent out, and serious trade loss due to irregularities of supply. The former does not represent a very grave monetary loss, but it is a question whether the nutritive value of such milk is equal to that of raw milk. The latter is, in the first instance, a trade loss, but since it amounts to 1*d.* a gallon, it represents an additional cost to the consumer of at least $\frac{1}{4}$ *d.* a quart. The sum of all these losses represents a very considerable wastage of foodstuff and also a serious financial loss; the question presents itself whether such losses are really necessary."

As time has passed the need for such work has been increasingly emphasized, since Hiscox⁸ has shown that lack of knowledge of the proper methods of handling milk lies at the root of grave faults which occur, not only in the cheese and whole-milk industries, but also in the condensed milk industry, in which very serious loss may be caused by the admission of yeasts to the milk. Indeed, we are informed that even biscuit making suffers from ignorance of this character.

A STUDY OF TWO TYPES OF COMMERCIAL MILK (10 & 11).

The fact that faulty methods of handling gave rise to such serious losses in different branches of the milk industry was a sufficient reason for carrying out investigations upon the subject. All the different aspects of the question could not be undertaken at one time. As a first step, therefore, it was decided to carry out a comparative series of tests between the cleanest commercial milk known to us and average milk from a better class farm. It was thought that in this way much knowledge could be obtained concerning the possibilities of handling milk under the conditions which then existed in England.

This work was begun in November 1916. It comprised the examination of samples of milk for bacteriological condition and duration of sweetness from two types of farms.

The one farm was producing milk under conditions which were better than the average conditions usually found on dairy farms. The milk from this farm was cooled sometimes, at others it remained uncooled. It came to the laboratory by road, a journey of not more than two to three miles. Its

bacteriological condition was tested within a minimum period of four hours and a maximum of twelve hours. The average age of the milk at the time of testing was nine hours. The tests for duration of sweetness were begun when the milk was three hours old.

The milk from the other farm was produced under exceptionally good conditions, the cows being milked in a special shed and every precaution being taken to ensure strict cleanliness. The milk from each cow was cooled immediately to temperatures which varied between 45° F. and 62° F. according to the season of the year, and immediately bottled. All milk utensils, bottles, &c. were efficiently washed and sterilised. The bottled milk was sent to the laboratory arriving after a period of 22–26 hours from the time of milking. No attempt was made to keep it cool on the journey. It was, therefore, receiving the least cooling at the most difficult time of the year, and the conditions of travelling were such that one sample reached the laboratory at a temperature of 76° F.

The results obtained were published (Freear, Buckley and Williams)^{9 and 10} and from these publications Charts I and II are extracted. These charts demonstrate that the bacteriological counts of the bottled milk only rose above 10,000 per 1 c.c. upon three occasions in the course of a series of examinations which extended over a period of more than two years, whereas those of the average milk showed an entirely different picture, in spite of the fact that its age at the time of examination was very much less than that of the clean milk (4 to 12 hours as compared with 22 to 26 hours); for while the bacterial count of the clean milk maintained an almost uniform level, that of the average milk varied greatly from week to week, so that on one occasion it was below ten thousand and on another fourteen millions or more. It was further found that whereas in clean cooled milk, organisms (such as *Bacillus coli*) capable of producing acid and gas in lactose peptone water were only present on ten occasions, and that the smallest quantity of milk in which they were obtained was 1/100 c.c., in the average milk they were found on sixty-five occasions, and the smallest quantity of milk in which they were present was 1/10,000 c.c. There was, therefore, a great difference in the bacterial content between these two sets of samples of milk, and this difference was not explained by the fact that the clean milk was cooled at the farm, whereas the average milk was only cooled during a period of about six weeks from November to January in each year. If the records of the samples of cooled average milk be examined, the same irregularity in the bacterial counts and in the evidence of the presence of lactose fermenting organisms is found as occurred during the months when the milk was not cooled. The demonstration of this fact was of value, for many members of the industry place far too much reliance upon excessive cold and do not realise that its action is purely inhibitory and its effect temporary.

CHART II.
BACTERIOLOGICAL EXAMINATIONS OF CLEAN COOLED MILK & AVERAGE UNCOOLED MILK

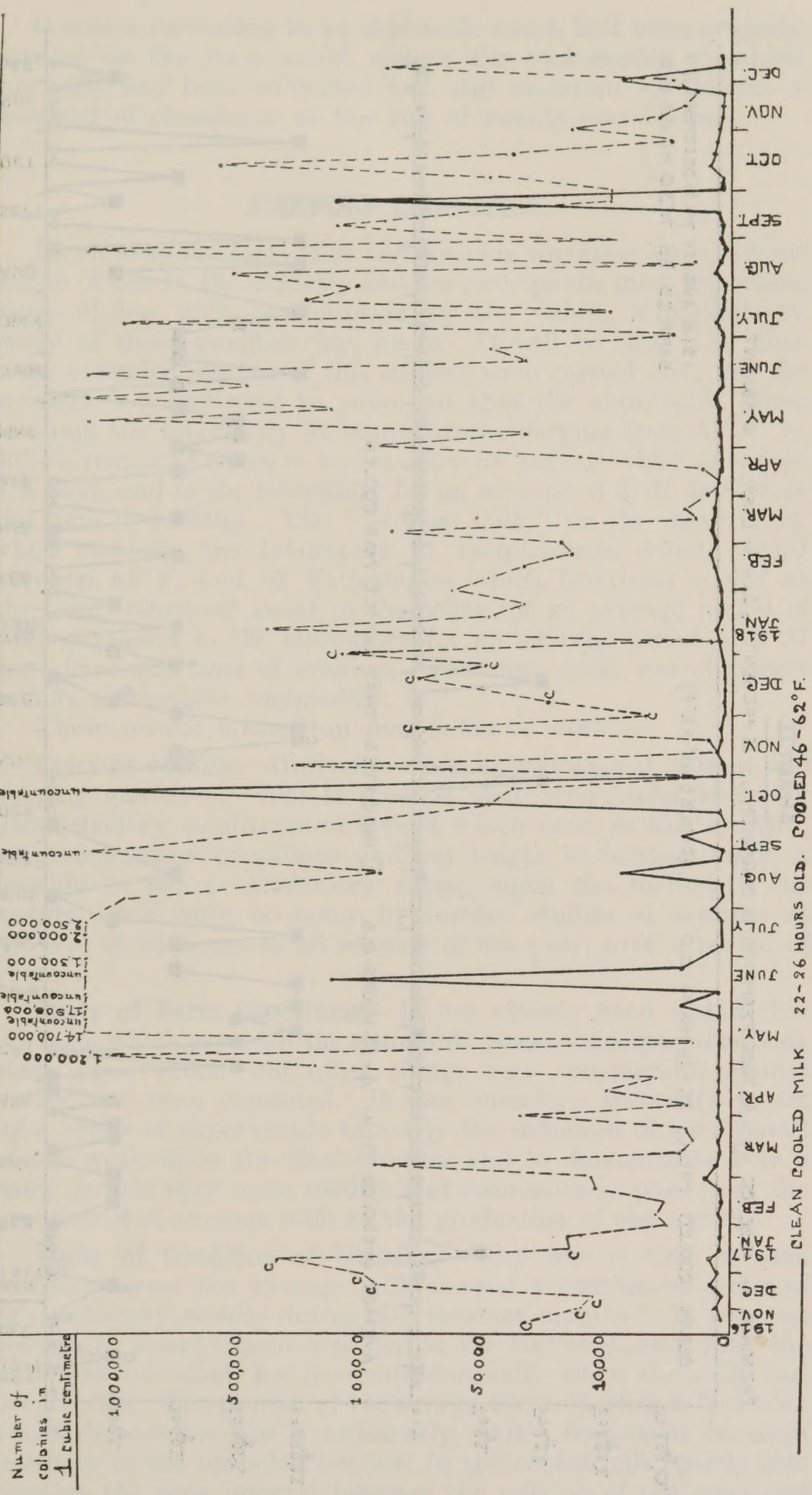
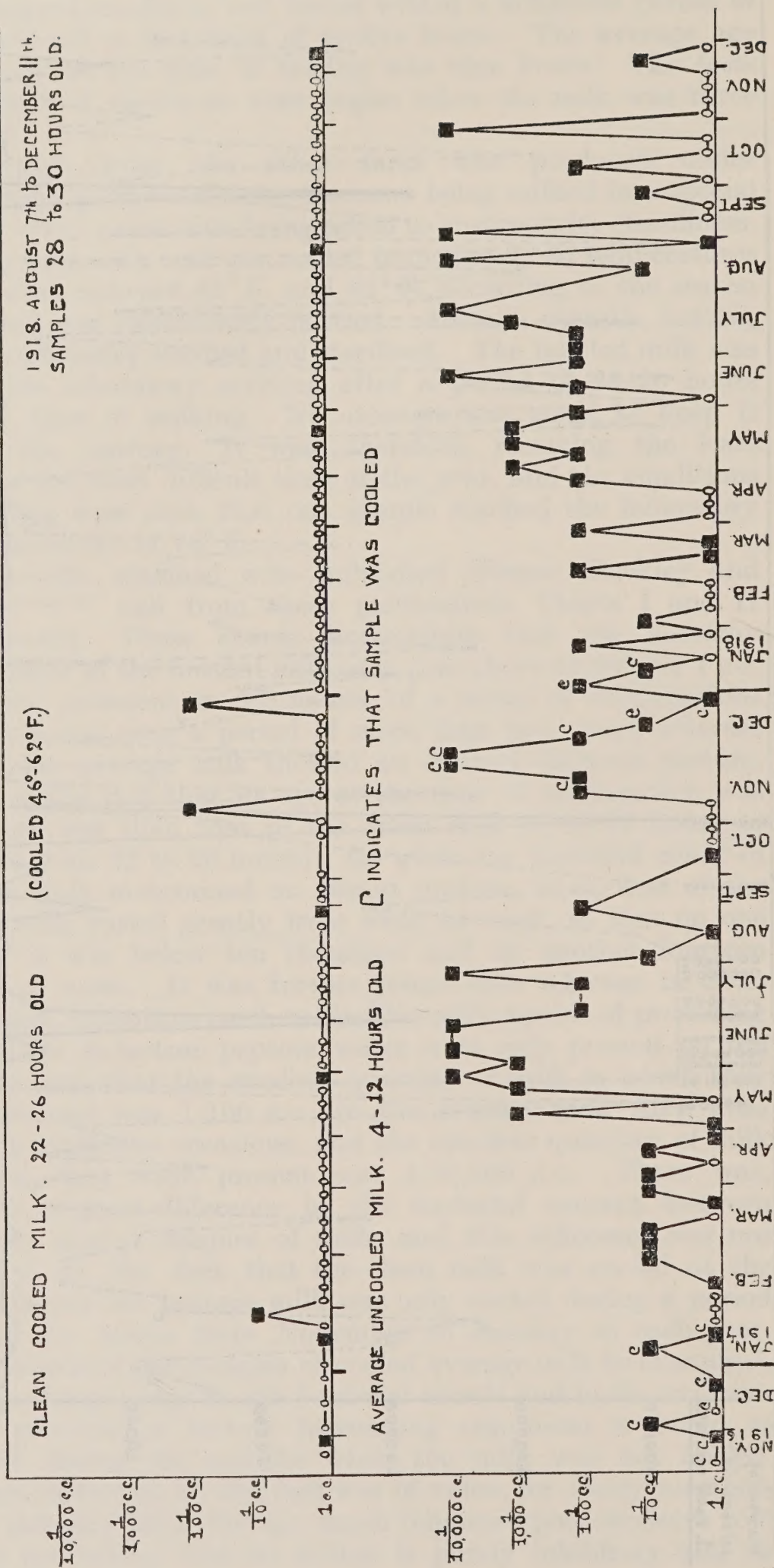


CHART II

PRESENCE OF ABSENCE OF LACTOSE FERMENTING ORGANISMS. PRESENT IN 1 cc or LESS. 0 ABSENT. 0 ABSENT.

1918. AUGUST 7th to DECEMBER 11th.
SAMPLES 28 to 30 HOURS OLD.



It was a revelation to us that milk which had been properly handled at the farm could endure the vicissitudes to which this milk had been subjected and still maintain so uniform a standard of cleanliness at the end of twenty-four hours.

KEEPING QUALITIES.

In view of the facts that bad keeping qualities are a serious source of loss to the industry and are perhaps the most important cause of low milk consumption by the public, a preliminary study of these qualities was made. It will be seen later that more extended studies of this subject were carried out; for the moment it is sufficient to point out that the clean milk, when reaching the laboratory at temperatures varying from 51° F. to 60° F., remained sweet in a cool cellar for periods which averaged 5·8 days, and in the laboratory for an average of 3·92 days from the time of milking. The "average milk," on the other hand, when reaching the laboratory at temperatures which varied between 46° F. and 53° F. (samples which had been cooled at the farm) remained sweet in the cellar for an average period of 3·75 days and in the laboratory for an average period of 2·37 days from the time of milking. The clean milk was obviously a more marketable commodity.

These results opened up new fields of work:—

Carriage of Milk.—(Influence upon bacteriological content and keeping qualities). Was it possible that even under the very unsatisfactory conditions of transit which exist in this country, our temperature conditions and our length of haulage made it feasible to put a satisfactory supply upon the market? The answer could only be made by further studies of samples at the end of 24 hours at all seasons of the year, over a period of years.

Study of Farm Conditions.—It has already been stated that the farm which provided the clean milk possessed a special milking shed, upon which and other things very considerable capital outlay had been expended. It was, therefore, necessary to set up a series of experiments to study the influence of each detail of the work upon the final product and to demonstrate how a dairy farmer may most readily and economically pass from the production of average milk to the production of clean milk.

Study of Condition of Utensils.—Why was it that in each successive year the average milk showed a continuous series of unsatisfactory results during the summer months? It was not enough to assert that it was due to the fact that, as a rule, the milk was uncooled, for it occurred equally when the milk had been cooled. The growth of bacteria in the milk after it had been taken did not explain it sufficiently, partly because it occurred not only in the uncooled but also in the cooled milk, partly also because the time interval between the milking of the cows and

the carrying out of the bacteriological examinations was short. The state of the cows could hardly be responsible, for they are cleaner in the summer when they are in the meadows than in the winter when in the cow sheds. It appeared to us that the chief explanation probably lay in the condition of the utensils which, being insufficiently washed and steamed and left damp, permitted the growth of bacteria between milkings, especially in the warmer weather. It was these observations which first led us to study in detail the methods of washing and steaming dairy utensils and milk churns.

It is important to note that the stages in which the work which has been outlined was undertaken were influenced by the facts that the Institute did not possess a dairy farm until October 1920, and that the number of members of staff was limited. Much of the work upon the study of the influence of conditions at the farm was, therefore, undertaken between the years 1920-1923, though valuable preliminary investigations were carried out at the College farm during 1918-1919.

The order of the work was further affected by political conditions, since, owing to the war, the Ministry of Food controlled the producer's price for milk. That price was insufficient to meet the costs of certain persons who, by virtue of their knowledge, enthusiasm and ability to create a limited market, were producing and selling milk of a quality very different from the average.

In 1917, therefore, the Ministry of Food, in co-operation with the Ministry of Health, issued special licences to those who wished to produce such milk enabling them to charge an extra price. During the succeeding years the conditions under which these licences were issued underwent various modifications which it is not necessary to describe here. It is sufficient to point out that until the Milk and Dairies Act (1922) was made effective in June 1923, they comprised two classes, Grade "A" (Certified) and Grade "A." The following table gives the order of events. (Stenhouse Williams & Mattick)¹¹

<i>Date.</i>	<i>System.</i>
September 1918	- Licence.
March 1920	- Licence A Licence B.
December 1920-22	- Grade A (Cert.) Grade A. (Bacteriological (No bacteriological test introduced.) test.)

These licences were only given to those whose cows did not react to the tuberculin test.

The Staff of the National Institute for Research in Dairying was working in collaboration with many of those who produced milk under these licences throughout the whole of these years. It was of importance that it should be so, for they not only learnt much themselves, but were in a position when the time came to offer facts and figures upon which bacteriological standards could be based.

STUDIES CONCERNING GRADE "A" (CERTIFIED) MILK.

It will have been noted that the studies which have been described of the bottled milk which under the scheme of the Ministry of Health was later described as Grade "A" (Certified) were carried out when that milk was 22-26 hours old. It appeared advisable that future work should also include the study of samples which were 30 hours old; thus a measure of the duration of time during which such milk would maintain its bacteriological cleanliness under ordinary atmospheric conditions could be obtained. That the conclusions reached might represent a just average, samples of milk from three further farms which were undertaking the provision of an improved milk supply were included. The work was carried on until January 1921, and results were published in October of that year¹² (Freear, Mattick, Williams). Table II is extracted from this paper and demonstrates clearly that the delay of six hours before the examinations of the milk samples were made materially increased the risk of failure to maintain either the New York standard of 10,000 colonies in 1 c.c. of milk or the newly instituted English standard of 30,000.

The facts contained in this paper were brought before members of the milk industry who were interested in providing the consumer with a better milk supply and they were asked to consider the age within which whole milk should reach the consumer. The general view appeared to be that it ought to be possible to supply the public with milk which was not more than twenty-four hours old. In order to emphasize still further the need for giving serious consideration to this question A. T. R. Mattick and Stenhouse Williams published a paper¹³ which contained the results obtained during the year 1921, set out not only in relation to the age of the samples, but also to the temperatures at which they reached the laboratory.

Table III is extracted from this paper; it confirms the observation which had been previously made, that properly produced milk delivered to the consumer at an age not greater than twenty-four hours, and at a temperature of not more than 60° F. may be expected to conform to the bacteriological standard of 30,000 per 1 c.c. as laid down in the regulations for Grade "A" (Certified) milk, and also that if the age of the milk exceeds 24 hours or the temperature is over 60° F. success is by no means certain.

It would be a very great help if those who are interested in promoting the sale of a better quality of whole, fresh milk would consider the facts which have been established and decide the limit of age within which graded milk shall reach the consumer. It would then be easier to pass on to the further problems of the methods of cooling and carriage of milk which need investigation.

TABLE II.
Comparison of Counts at the end of 24 and 30 hours.

Farm.	Age of Milk in Hours.	No. of Samples.	10,000 Standard.		30,000 Standard.		No. of Samples showing Acid and Gas in 1 c.c. or less.	Percentage of Samples showing Acid and Gas in 1 c.c. or less.
			No. of counts above 10,000.	Percentage of counts above 10,000.	No. of counts above 30,000.	Percentage of counts above 30,000.		
I., II. and IV.	-	201	12	6.0	7	3.5	41	20.6
I., III. "A" and "B"	-	219	41	18.7	21	9.6	70	32.0

TABLE III.
The Influence of Age and Temperature upon the Bacteriological Counts of Grade "A" (Certified) Milk.

Age (hours).	No. of Samples.	Temp. on arrival at laboratory, 41-50° F.		Temp. on arrival at laboratory, 51-60° F.		Temp. on arrival at laboratory, 61-70° F.		Temp. on arrival at laboratory, 71-75° F.		Temp. on arrival at laboratory, over 75° F.	
		Counts under 30,000 per c.c.	Counts over 30,000 per c.c.	Counts under 30,000 per c.c.	Counts over 30,000 per c.c.	Counts under 30,000 per c.c.	Counts over 30,000 per c.c.	Counts under 30,000 per c.c.	Counts over 30,000 per c.c.	Counts under 30,000 per c.c.	Counts over 30,000 per c.c.
24	-	19	0	35	1	22	8	2	3	-	-
30	-	27	2	62	8	38	48	0	20	1	2

THE KEEPING QUALITIES OF GRADE "A" (CERTIFIED) MILK AT ROOM TEMPERATURES AND IN A COOL CELLAR.

If there is to be an increase in the consumption of milk it is essential that it shall remain sweet in the consumer's house between deliveries; the work, therefore, upon the keeping qualities of Grade "A" (Certified) milk has been continued and two further papers have been published ^{13 & 14}. Table IV epitomised from the first of these demonstrates the average duration of sweetness of samples of milk which reached the laboratory during the period August 1918–August 1919. These samples were about 30 hours old on arrival at the Institute and were subsequently kept either in the cellar or in the laboratory, which was subject to wide variations in temperature.

TABLE IV.

No. of Samples.	Temperature on arrival °F.	Age on arrival (hours).	Days sweet from time of milking.	
			Cellar.	Laboratory.
1 - -	40 or less	30	15.5	9.5
15 - -	41–50	30	7.7	5.5
17 - -	51–60	30	5.0	4.25
16 - -	61–70	30	3.6	2.8
1 - -	73	29	3.5	2.5
1 - -	76	28	3.5	2.5

These results were so astonishingly good that it was felt right to continue the work; and in view of the fact that the minimum period during which milk will remain sweet, under the conditions of temperature and haulage which exists in this country, is of the utmost importance to the industry and the consumer, the results in the second paper were expressed in these terms. The work was carried out during the year 1921 which, as it happened, showed prolonged high temperatures and was one of great difficulty for the milk industry. The milk was obtained from two farms which were producing Grade "A" (Certified) milk. It was already 30–32 hours old when delivered at the laboratory. A summary of the results is shown in Table V (Mattick and Williams).

This table confirms the work upon sweetness which has been previously mentioned and shows that even in the laboratory in which the average maximum temperature throughout the summer period was 72° F. all samples which arrived at 60° F. or less remained sweet for at least 48 hours from the time of milking and only one was sour at the end of 60 hours. That being so, a once a day delivery should suffice, certainly throughout the greater part of the year. It is a notable fact that despite the very high

temperatures encountered by many of the samples, none remained sweet for less than one and a half days from the time of milking, even when kept in the laboratory.

STUDIES CONCERNING GRADE "A" MILK.

When graded milk was first instituted the members of the staff of the Institute urged the necessity for a bacteriological standard for such milk. Their reason for doing so was twofold. Firstly they knew from experience that few people in the industry had a real knowledge of the essentials for success, and had watched cases of complete failure even when much money had been expended in providing all the necessary plant, the reason of the failure being the lack of knowledge of those who were carrying out the work. Secondly, graded milk costs more to produce than ordinary milk. It was being offered to the consumer as something which could be relied upon to remain sweet between deliveries; if it failed in this respect grave injury must be done to a method of handling milk which offered a great future, but was still in its infancy.

In 1920 a bacteriological standard was introduced for Grade "A" (Certified) milk which was obtained from cows which did not react to the tuberculin test and which was bottled at the farm; but no test was set up for Grade "A" milk, which also came from cows which did not react to the tuberculin test, but was permitted to be bottled at a dealer's premises. It was fortunate for us that the farmers in the neighbourhood of Reading took up this grade of milk and set themselves to work to clear their herds of reacting cows and make necessary alterations to their cowsheds, &c. The staff of the Institute worked with them and in June 1923 A. T. R. Mattick and Stenhouse Williams¹⁵ published a paper which demonstrated the inequality of the results obtained on two farms licenced under this system, and the need for a bacteriological standard. An epitome of these results is shown in Table VI.

TABLE VI.
Grade "A" Milk 1-2 hours old.

No. of colonies per c.c.	FARM V.		FARM VI.	
	No. of samples.	No. of occasions when lactose fermenting organisms occurred.	No. of samples.	No. of occasions when lactose fermenting organisms occurred.
1,000 or less	13	2	0	0
5,000 "	33	4	9	1
10,000 "	11	2	7	3
30,000 "	10	1	27	8
Over 30,000	5	1	32	29
	72	10	75	41

The samples from which these examinations were made were taken from the churns, immediately after the milk had passed over the cooler, by means of sterile dippers and were poured into sterile bottles. They were examined within two hours of milking. The table shows clearly the great difference in bacteriological content which was found to occur. With reference to these results the following paragraph may be quoted from the original paper :—

“ In view of the difficulty which is sometimes found in bringing the standard of labour on a farm up to the required level, we feel that evidence that milk of the required standard of cleanliness is being produced should be made a condition of licensing. If this be not done there is a danger that milk which is not of the necessary cleanliness may be sold as Grade “ A.” In that case the consumer may find that the keeping qualities of this milk are no better than those of the milk which had been previously purchased. If this occurs grave harm may be done to the milk industry, which is endeavouring to supply the public with a milk of uniform quality. It is, therefore, in the interests of the milk industry that such a standard as has been suggested shall be set up for Grade “ A ” milk.”

A bacteriological standard for this type of milk was set up under the Milk and Dairies (Amendment) Act, 1922, and came into force in January 1923. In addition it is customary to require evidence from those who are applicants for licences that “ they can deliver the goods.”

KEEPING QUALITIES OF GRADE “ A ” MILK.

The study of this problem is now being carried out at the Institute and the results will be published in due course. In the meantime the work which has been carried out upon the keeping qualities of certified milk, which had travelled in small bulk and had endured all the variations in temperature which it might encounter, has made clear the very wonderful keeping qualities which milk possesses even under disadvantageous conditions. It has also shown that with the temperature conditions and length of haulage which exists in this country it should be possible to put a whole fresh milk into the consumer's house which will remain sweet for 24 hours during most seasons of the year. This has been found to be true in Reading, where Grade “ A ” (Tuberculin Tested) milk, some of which is derived from local farms, and some of which comes by rail, is delivered to the consumer on the following morning at about 7 o'clock and is still sweet when the next delivery is made at the same hour on the following day. One consumer who has been taking such milk from two retailers for a period of eighteen months, has only found it go sour on two occasions during this period. In effect such a method of handling milk assumes its capacity to remain sweet for 48 hours from the

time of milking, without any further cooling at the farm or any more care during transit than is customary at the present time.

It is the view of the staff of the Institute that this is asking too much during the warm weather and that under such a system there will be cases of failure. It is of the utmost importance to the future of the industry that it shall be in a position to provide the consumer with a milk which will remain sweet in his house. It appears that this could be done in one or other of the following ways :—

(1) Increase the number of deliveries of milk during warm weather so that its consumption in the consumer's house shall have ceased when it is not more than 36 hours old.

(2) Ensure more efficient cooling at the farm and during transit and maintain the period during which the milk shall remain sweet.

It is more than likely that either of these or some other method may suit different districts. The serious consideration of these problems by the industry would be of the greatest help to the staff of the Institute, who could then carry out the work which must be done upon the transit of milk in the manner most helpful to the industry.

THE BACTERIOLOGICAL STANDARDS—CAN THEY BE MAINTAINED ?

Certified Milk.—Subject to the conditions of time and temperature which have been set forth, the evidence that the bacteriological standard for what was formerly known as Grade "A" (Certified) milk, but is now called Certified Milk, can be maintained is to be found in Charts I and II and in Tables II and III.

On some of these farms very considerable sums of money had been expended upon buildings and plant. It is of interest, therefore, to include here the hitherto unpublished results attained by a dairy farmer working under simpler conditions during the year 1921, a difficult year for the milk trade.

TABLE VII.

Date.	Age in hours.	Temp. Cooling.	Temp. Testing.	No. of colonies of bacteria per 1 c.c.	<i>Bacillus coli</i> present in
7.1.21	21	49	56	4,450	+1/10 c.c.
14.1.21	21	48	52	12,800	—
21.1.21	26	49	52	850	—
28.1.21	20	49	59	2,700	—
4.2.21	25	48	50	870	—

TABLE VII.—*continued.*

Date.	Age in hours.	Temp. Cooling.	Temp. Testing.	No. of colonies of bacteria per 1 c.c.	<i>Bacillus coli</i> present in
10.2.21	20	45	53	4,790	—
18.2.21	20	47	59	3,380	—
25.2.21	25	46	48	640	—
11.3.21	20	46	59	1,000	—
1.4.21	26	49	65	1,420	—
8.4.21	25	59	53	2,500	—
15.4.21	21	49	48	20	—
22.4.21	20	48	56	280	—
29.4.21	22	54	61	570	—
6.5.21	20	52	56	20	—
13.5.21	20	54	60	140	—
20.5.21	25	55	65	790	+ 1 c.c.
27.5.21	22	59	61	300	—
3.6.21	22	57	47	500	—
10.6.21	20	58	60	70	—
17.6.21	22	60	69	1,190	—
1.7.21	22	60	63	2,160	—
8.7.21	20	64	67	2,910	—
15.7.21	25	56	72	306,000	—
22.7.21	20	46	66	3,150	—
29.7.21	20	50	68	580	—
5.8.21	24	60	66	800	—
12.8.21	26	46	62	380	—
19.8.21	20	50	66	70	—
26.8.21	21	48	61	1,820	—
2.9.21	20	52	65	1,020	—
9.9.21	29	48	64	Uncountable	+ 1 c.c.
16.9.21	21	50	57	230	—
23.9.21	22	50	66	23,800	—
7.10.21	21	45	66	1,180	—
14.10.21	22	50	67	1,000	—
21.10.21	22	46	59	470	+ 1 c.c.
4.11.21	20	55	62	430	—
11.11.21	21	49	50	190	—
18.11.21	21	48	55	540	—
25.11.21	21	47	54	800	—
29.11.21	21	—	50	5,200	—
2.12.21	22	48	53	200	—
9.12.21	21	—	56	1,000	—
13.12.21	25	—	51	6,900	—
16.12.21	23	48	52	220	—
30.12.21	21	49	50	400	—

These results show that this certified milk producer failed to maintain the standard of 30,000 colonies of bacteria per 1 c.c. on two occasions during the course of the year and his milk showed the presence of *B. coli* in 1/10 c.c. on one occasion. It is clear, therefore, that it is possible to maintain the standard.

Grade "A" Milk.—It is obvious that more work remains to be done upon the standards which have been set up for Grade "A" milk, since they only came into force in January 1923, but as

milk of this character was put upon the market in Reading early in the year 1922 it has been possible to gather together a certain number of figures concerning its bacteriological condition, both before and since a standard was instituted. These were brought before a Conference on the Milk Question at the Royal Society of Arts in May 1923.¹⁶ The facts which were put before the meeting showed the condition of Grade "A" (Tuberculin Tested) milk as it reached the consumers in Reading from three different distributors in the town between May 26th, 1922, and April 13th, 1923; since that time further examinations of the milk supplied by these distributors have been carried out and a summary of the results obtained to the end of June 1923 is given.

TABLE VIIIA.

Series.	No. of samples.	Certified Standard 30,000 per 1 c.c.		Grade "A" Standard 200,000 per 1 c.c.	
		No. within standard.	No. above standard.	No. within standard.	No. above standard.
Series 1 -	44	40	4	43	1
" 2 -	25	19	6	23	2
" 3 -	26	15	11	26	0
Total -	95	74	21	92	3

TABLE VIIIB.

Examination for Bacillus coli.

Series.	No. of samples.	Absent in 1 c.c.	<i>B. coli</i> present in			
			1 c.c.	1/10 c.c.	1/100 c.c.	1/1,000 c.c.
Series 1	44	28	16	10	6	4
" 2	25	17	8	3	1	1
" 3	26	18	8	3	1	1
Total	95	63	32	16	8	6

These results show that it is quite possible to maintain a standard of 200,000 colonies in 1 c.c. and absence of *B. coli* in 1/100 c.c. on delivery of milk to the consumer, since failure to keep the former standard only occurred three times in the course

of 95 examinations and the latter standard eight times in a similar number of examinations. It is to be noted that the standard for Grade "A" milk did not come into force until January 1923. Many of these examinations, therefore, were made at a time when the producers and distributors were without any legal stimulus.

THE FUTURE OF GRADED MILK.

At the present time it is possible to obtain licences for the production of three types of graded milk. (1) Certified milk must be bottled at the farm from cows which do not react to the tuberculin test and are subject to veterinary inspection, (2) Grade "A" (Tuberculin Tested) milk may be sent in sealed churns to be bottled at a dealer's premises. This type of milk must also be produced from cows which do not react to the tuberculin test and are subject to veterinary inspection. The Producers' Licence for either of these types is held directly under the Ministry of Health. (3) Grade "A" milk may also be sent in sealed churns to be bottled at a dealer's premises. This milk is obtained from cows which are not subject to the tuberculin test, but are submitted to regular veterinary inspection. The Producers' Licence is held under the local authority.

The ultimate success or failure of these types of milk will depend to a great extent upon their quality and their price. In the term quality are included maintenance of sweetness between deliveries and freedom from disease-producing bacteria.

Certified milk provides such a guarantee that it satisfies the public mind. Unfortunately its price in the past has been too high to admit of its forming any very large proportion of the fresh milk supply of this country. On the other hand there is evidence that in districts remote from large urban centres, milk of this character may be sold retail at rates much below those which are charged in the urban centres. Such supplies can be found in Penrith, Bridgend, Milford Haven and Haverfordwest, possibly also at other places, at prices which in some cases are no higher than those charged in the same district for ordinary milk. It should be remembered that in these cases the producer is also the retailer, and has created a local market. The whole of the proceeds, therefore, remain with him. If such centres can be spread throughout the country, they must produce an enormous improvement in the milk supplies in rural districts.

The cost for Certified milk in the great towns remains, however, too great for the average consumer. None the less this type of milk has made its position, and, within limits, is assured of a market.

The future of Grade "A" (Tuberculin Tested) is not yet clear. It has only been upon the market for about eighteen months, and

as is usual with a new venture it has had to encounter very serious opposition. Where, however, it has been supported it has proved itself to be a success. In Reading, where it was first put upon the market at the beginning of 1922, the sales have gone up greatly and there are now five distributors of this milk in the town, and most of the smaller towns in the neighbourhood have now got supplies of this character. In Newcastle also, considerable quantities of this milk are sold. It has the great advantage that its price is not more than about one penny a quart more than that of ordinary milk, and the poor are willing to buy it, chiefly because its keeping qualities are so much better than that of the milk to which they have been accustomed.

We have no means of gauging what the future of Grade "A" milk will be. Its duration of sweetness should be equal to that of Grade "A" (Tuberculin Tested) milk. Will the fact that veterinary inspection alone does not give so complete a guarantee of freedom from disease as veterinary inspection plus tuberculin test militate against its sale? It is impossible to say.

STUDIES OF FACTORS CONCERNED IN PROVIDING A CLEAN MILK SUPPLY.

The Farm.—Utensils.—Workers.—It has already been pointed out that the study of the bacteriological content of commercial clean milk and of its keeping qualities began in 1916, and that it came from a farm on which considerable sums of money had been expended in order that the best results might be attained. It was quite clear that if the expenditure of similar sums of money was necessary before a farm could undertake clean milk production, then progress must be much delayed. Moreover, the staff of the Institute knew that other farms, which had expended similar sums of money on buildings and plant, had not, at that time, attained like results. It was clear that much depended upon the worker; it was therefore, essential to study the details necessary for success on the most economical lines and put the results into the hands of the milk producer.

The earliest work was carried out during the years 1918–19, and was published in 1920,¹⁷ (Knight, Freear & Stenhouse Williams).

It consisted of a series of five experiments carried out in a cowshed which was of the better type. Table IX shows that the series included a study of the relative values of the open and covered pails, of comparisons between the results obtained when the utensils were washed, or washed and steamed, and of the effects obtained when the cows were ungroomed, or had had the long hairs about their udders clipped, or had had their udders washed and dried. Throughout the experiments the same clean milker was employed.

TABLE IX.

Date.	—	No. of Experiments.	Buckets.	Number of samples showing more than 10,000 colonies in 1 c.c. of milk.	Average of colonies found in 1 c.c. of milk in remaining samples.
Series 1. Oct. 12 to Nov. 13.	Buckets washed by farm hands.	12	Open Covered	2 10	2,360 10,000
Series 2. Nov. 13 Dec. 14.	Buckets washed by clean milker (farm method)	14	Open Covered	1 2	3,200 3,991
Series 3. Jan. 11 to Mar. 3.	Buckets washed and steamed, cows un- groomed.	30	Open Covered	5 0	4,274 1,505
Series 4. Mar. 5 to June 20.	Buckets washed and steamed. Cow's udders clipped.	51	Open Covered	10 2	2,505 516
Series 5. June 23 to Sep. 4.	Buckets washed and steamed. Udders clipped, cows washed and dried.	42	Open Covered	2 2	900 388

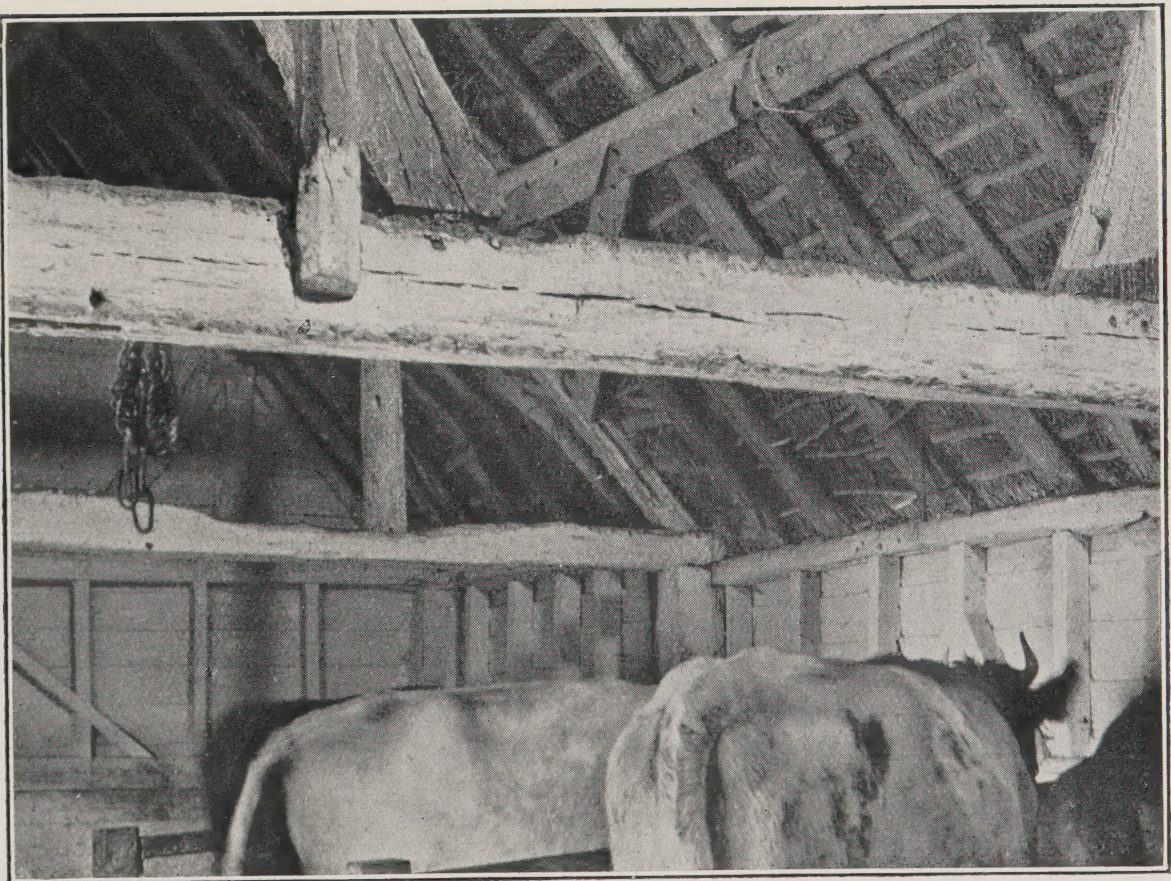
In addition to showing the influence of a clean cow and properly steamed covered bucket upon the final product, this study revealed to us the immense importance of the personal factor in all this work and the need for the study of the details of washing and steaming that these might be carried out on efficient lines with a due regard to economy of time and labour.

A comparison of Series 1 with Series 2 is a good illustration of what is meant. In Series 1 the buckets, open and covered, were washed by the farm hands with warm water and a cloth in accordance with the usual practice. The table shows that the milk taken into the covered bucket contained many more bacteria than that taken into the open bucket. When, however, the clean milker washed the bucket (Series 2) this difference disappeared, although the clean milker was also using warm water and the same cloth for the work. The difference was due to the mentality of the two types of workers. The clean milker really understood what she was aiming at; the farm workers did not, and as it was a little more difficult to see the angles in the covered bucket, they were insufficiently cleansed and rapidly accumulated a layer of dried milk.

The futility of putting new apparatus into the hands of workers without ensuring that they are made to understand its proper use was thus made clear.

It was obvious that a new mentality must be created and any work carried out must be done in such a way that it would reach the dairy community. Subsequent work has, therefore, been

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published chiefly in the various dairy journals, and in addition large numbers of reprints have been spread throughout the country. The necessary experiments were begun in the old cowshed (see illustration) when the Institute first came into possession of a farm in the year 1920.

This shed was unevenly cobbled and badly lit. There was no dairy, but an abundant supply of water could be obtained from a hand pump in the yard. The workers washed and stored their utensils in the position shown in the photograph. The utensils were steamed in the cowshed itself just before milking took place, and hot water taken from the steamer was used to assist the washing up after the milking was finished. The work was done under considerable disadvantages. Nevertheless the condition of the milk was converted from very average to clean. Some of the bacteriological counts which were obtained during February and March 1921 have been extracted from a paper by Hoy, Sargeant and Williams,¹⁸ and are shown in Table X.

TABLE X.

Milk 4-8 hours old.

No. of colonies in 1 c.c. of milk.	<i>B. coli</i> present in
770	—
730	+ 1 c.c.
530	—
510	—
280	—
80	—
20	—

This work was carried out under conditions which were not just to the workers.

At a small cost, therefore, standings for the cows were put in, and a gutter made. The thatched roof still remains, but is kept clean and lime spray is freely used.

The photograph demonstrates how greatly these small improvements have affected the lighting and look of the interior of the shed. A calf shed across the yard has been converted into a dairy by putting in an impervious floor and a few wooden fittings. The water is still carried by hand across the yard, galvanised baths are used for washing up, and a simple steam sterilizer is used for the sterilization of all utensils.

The whole of the improvements are of a very modest description, but make the work much pleasanter. Mackintosh¹⁹ has pointed out the importance of improved conditions to those who are responsible for the work.

Under these conditions further experiments were carried out, and a paper was published in 1922²⁰ (Hoy, Sargeant and Williams). This paper contains a careful description of the methods necessary for the production and cooling of milk on the

farm. It seems to be in a form which meets the need of the dairy farmers, for great numbers of copies have been demanded.

Quite recently (1923) the facts contained in these reprints and much further matter have been gathered together by A. T. R. Mattick and published in pamphlet form by *The Dairyman*.²¹

It is interesting to record that when experiments with the covered buckets were first begun at the Institute, only a very few people used them, and there was practically only one type available. Since that time, however, so many different types have been brought out in this country that it has been necessary to carry out experiments which demonstrate the influence that the size of the opening and the degree to which it is set back have upon the final cleanliness of the milk. This work has now been done by Hickson and is about to be published.

The National Institute for Research in Dairying, though producing milk under the difficult conditions of which the photograph of the cowshed is a demonstration, yet possesses a licence for the production of Grade "A" (Tuberculin Tested) milk. Such a result could only be attained by intimate collaboration between the workers in the cowshed and those in the laboratory. It is by the spread of similar collaboration throughout the industry that the improvement of the milk supply of this country will be made.

STEAM STERILIZATION.

This subject is one that vitally influences success or failure in the handling of milk in all departments of the industry. The efficient use of steam is as important to the factory manager, wholesaler, retailer and dairy teacher as it is to the dairy farmer. In the past its efficient use has not been studied, with consequences which have had deleterious effects upon the industry.

The work upon this subject which was undertaken by the staff of the Institute arose from a variety of different causes. Among these may be mentioned that it was almost impossible for anyone who knew what efficient sterilization really involved to enter into any dairy premises without observing numerous instances of obvious failure to produce the desired result. The immense importance to the industry of efficient washing and sterilization had not been realized, and consequently those who did the work had not received the training in physics which is necessary, and that mind which visualises "dirt" when none can be seen with the naked eye.

It was a duty, therefore, to study steam sterilization as it applies to dairy problems and to do it in such a way as to reduce time, labour, and costs to a minimum.

Two events led up to the immediate work. In the autumn of 1919, Cumming and A. T. R. Mattick²² tested the cleanliness of five hundred empty milk churns on a station platform with results that are shown in Table XI.

TABLE XI.

Classification of Churns by Inspection, October 9th—November 20th 1919.

Clean and Sweet.		Milk absent; evil smell.		Churn not washed, milk present.	Churn badly washed.
Dry.	Wet.	Dry.	Wet.		
81 16°/.	140 28°/.	5 1°/.	118 24°/.	81 16°/.	75 15°/.

Total ... 500.

When it is remembered that it is the duty of the person who receives the milk to see that the churns are adequately washed and steamed before they are returned, it is clear that there was grave failure in the carrying out of this work, a failure which it would be extremely difficult to remedy at the farm if the churns were on rail for any time.

How seriously this failure might affect any milk which was put into these churns subsequently is revealed by Table XII.

TABLE XII.

Bacteriological Examination, October 9th—November 20th, 1919.

Condition of Churn.	Counts. — No. of colonies of bacteria per 1 c.c.	<i>Bacillus coli</i> present in
Unwashed (whole milk present)	Uncountable in 1/100,000 c.c.	+1/100,000 c.c.
“ “ “	4,000,000	+1/100,000 c.c.
“ “ “	Uncountable in 1/10,000 c.c.	+1/10,000 c.c.
Badly washed (milky water present).	18,400,000	+1/1,000 c.c.
“ “ “	5,300,000	+1/1,000 c.c.
Apparently clean but wet -	4,100,000	+1/100 c.c.
“ “ -	780,000	+1/10,000 c.c.
“ “ -	510,000	+1 c.c.
“ and dry -	6,200,000	+1/1,000 c.c.
“ “ -	1,720,000	+1/10,000 c.c.
“ “ -	1,600,000	+1/100 c.c.
“ “ -	800,000	+1 c.c.
“ “ -	400,000	+1/1,000 c.c.
“ “ -	35,000	+1/10 c.c.
“ “ -	15,400	+1 c.c.
“ “ -	6,500	—
“ “ -	5,000	+1/10 c.c.
“ “ -	3,000	—
“ “ -	2,400	—
“ “ -	2,000	—
“ “ -	170	—

“ This table shows that the best of the churns contained 170 bacteria per cubic centimetre of washings. Therefore, as one litre of saline solution was used for washing, there must have been at least 170,000 bacteria in the churn. Another churn was found to contain at least 18,400,000 bacteria per cubic centimetre of washings. If 17 gallons of milk were put into this churn, that milk would start on its journey to the factory or consumer with an initial contamination of approximately 240,000 bacteria per cubic centimetre. These are the results of an examination in winter when temperature conditions were not favourable for the rapid proliferation of organisms. It is probable that in summer, milk such as this would arrive at the end of a long railway journey in such a condition as to be unfit for use.”

“ This investigation proves that the present methods of washing and cleansing churns are inadequate and are, therefore, a cause of loss of milk through souring in transit.”

At about the time when this work was being carried out at the Institute a request was received from the National Clean Milk Society that the Institute should test a simple steam sterilizer designed for use on farms where no other source of steam is available. This apparatus had been described by Ayres and Taylor in Farmers' Bulletin No. 748, of the United States Department of Agriculture. The staff of the Institute were very glad to accede to this request as it gave them an opportunity of considering the conditions necessary for success when current steam was being used, and in 1921 a report by Hoy and Stenhouse Williams was published.²³ A. T. R. Mattick²⁴ on the other hand, undertook the study of the effects of steam under pressure under commercial conditions.

Hoy and Williams demonstrated that if effective sterilization were to be obtained it must be carried out under fixed conditions and described the conditions as follows:—

“ (1) The source of heat must be such that steam at 210° F. issues from the outlet pipe within a limited time. In these experiments, in which the largest vessel to be steamed was a seventeen-gallon churn, satisfactory results were not obtained until the source of heat when applied to one gallon of water at 60° F. was sufficiently great to produce steam at 210° F. at the outlet pipe, within ten minutes of its first application.

(2) The source of heat must maintain its intensity throughout the steaming.

(3) All milk utensils, including milk churns, should be covered while being steamed.

(4) The steaming should be carried out in a place free from draughts.

(5) An accurate thermometer is *essential*.”

They further laid down the exact time required for success and gave a number of illustrative charts and tables showing the

effects of steam generated at too low temperatures and of the influence of draughts or absence of covering upon the final result.

One day it occurred to a member of the staff that after all it was probable that the ordinary farm copper could be converted to the uses of the simple steam sterilizer. As it happened there was an old copper in the cellar of the Institute. Within an hour or two, a hole had been made through its lid, a cigarette tin with the bottom knocked out had been pushed through and an inverted milk churn was being successfully sterilized. Hence arose the work which was published by Hoy²⁵ and has proved to be invaluable in promoting clean milk production. A. T. R. Mattick's work on the sterilization of milk churns by steam under pressure demonstrated the very varying temperatures (89° C. to 105° C.) at which steam from a boiler may be given off at the jet. As these were fluctuations liable to occur in practice he accepted them and proved that three minutes are required for the efficient sterilization of 17-gallon churns. Table XIII gives an epitome of the results which he obtained.

In constructing this table, all those results giving 500 or less bacteria per 1 c.c. of washings, are shown as percentages of the total number of experiments in the series. Five hundred bacteria per 1 c.c. of washings represent a total of 500,000 bacteria in the churn. Assuming that 17 gallons of milk are put into the churn, this figure means an addition of 7 bacteria per 1 c.c. of milk.

TABLE XIII.

Time of steaming.	No. of experiments.	500 bacteria or less per 1 c.c. of washings.	Percentage of counts of 500 or less per 1 c.c. of washings.
30 seconds	38	26	68 per cent.
2 minutes	45	39	86 per cent.
3 minutes	37	35	94·6 per cent.
		No. of occasions when lactose fermenting organisms were present.	Percentage of occasions when lactose fermenting organisms were present.
30 seconds	38	13	34 per cent.
2 minutes	45	6	13·3 per cent.
3 minutes	37	0	0 per cent.

The figures clearly demonstrate the fact that, as the time of steaming increases, the number of bacteria finally found in the churn decreases. When the time of steaming was 30 seconds, only 68 per cent. of the churns examined showed counts as low as 500 or less, as compared with 86 per cent. after two minutes' and 94·6 per cent. after three minutes' steaming.

The superiority of a period of three minutes' over two minutes' steaming is further demonstrated by a consideration of the percentages of occasions when lactose fermenting organisms

occurred. After 30 seconds' steaming lactose fermenting organisms were found on 34 per cent. of occasions, as compared with 13 per cent. after two minutes' steaming and 0 per cent. after three minutes' steaming.

It is true that if empty milk churns be examined on rail to-day a lamentable number will still be found to be in a deplorable state. It is true that the old cry that it is commercially impossible to sterilize churns for 3 minutes is raised. It is, however, also true that some efficiently wash and steam their churns according to the methods which have been laid down and, as a result, return to the farmer a properly steamed and dry churn ready for use.

While on this subject it may be well to speak of the process of "scalding," which may mean anything from a superficial rinse with tepid water to the use of water that was really boiling when it was put in the vessel.

As a fact, experiments by Hoy and Proctor (unpublished) which have been carried out at the Institute have demonstrated that two gallons of actively boiling water, when carried up a short flight of stairs, experienced a drop of 13° F. and a further drop of 32° F. during half a minute's scalding of a ten-gallon churn. The total fall of temperature was almost 46° F., but the most efficient heat had been lost before the water reached the churns in spite of the fact that everything was done as rapidly as possible. The above figures represent the average of results obtained from fourteen tests.

The following table also shows that the efficiency of scalding when carried out under ideal conditions was not to be compared with that of steam sterilization in preserving the sweetness of milk in churns which had been thus treated.

TABLE XIV.

*Keeping Qualities of Milk in Churns treated in Different Ways.
Number of Days Sweet at 60° F.*

Date.		* Control.	Washed.	Scalded.	Steamed.
28.11.22	-	4	$1\frac{1}{2}$	2	4
5.12.22	-	$3\frac{1}{2}$	$1\frac{1}{2}$	2	$3\frac{1}{2}$
9.12.22	-	$3\frac{1}{2}$	$1\frac{1}{2}$	2	$3\frac{1}{2}$

* The control milk remained in the sterile vessel into which it had been milked.

In practice it has been found that many members of the milk industry who are sincerely anxious to do good work have not yet grasped the essentials for success. They do not understand that steam to be effective must (1) be at a definite temperature; (2) be allowed to act for a specific time and, as a corollary of

(1), must be kept in an enclosed space. Hence the opportunity has been seized as the occasion arose of publishing subsidiary notes on these subjects in dairy journals.

It was thus that Stenhouse Williams²⁶ wrote an article in the Essex Farmers' Union Yearbook, pointing out that spraying a jet of steam on to an exposed cooler failed to sterilize the cooler, and E. C. V. Mattick and Hallett²⁷ demonstrated that clean milk, which was put into well cleaned but unsteamed vessels and pasteurized, contained a greater number of bacteria than the clean milk from which it had been derived.

VENTILATED AND UNVENTILATED CHURNS.

It may be advisable to mention here a collateral series of investigations which Golding, Cornish and Williams undertook at the request of the Ministry of Agriculture and Fisheries during the years 1914-1916. Reports upon these investigations were submitted to the Ministry in November 1914 and January 1916. A summary of the results was published in the Ministry's *Journal*,²⁸ Volume XXIII, 1916, and the full reports were published as a Supplement to the *Journal* in December 1919²⁹. These reports were concerned with the influence of air upon the growth of organisms in milk and with the need or otherwise for the ventilation of milk churns. It happened that Moore and Williams³⁰ and Adams³¹ had already carried out work on the influence of oxygen upon the growth of bacteria which was of value in considering this problem. The results of these experiments demonstrated that the ventilation of milk churns does not assist the keeping quality of milk, but is rather an added risk, since ventilation increases the danger of dirt contamination. It seems so obvious now, when all graded milk is successfully carried in sealed churns, but at the time the work was done, many held that ventilated churns were necessary for the successful carriage of whole milk.

THE IMPORTANCE OF CLEAN MILK IN MILK INDUSTRIES OTHER THAN THE WHOLE-MILK TRADE.

From the earliest days the importance of clean milk, not only to the whole-milk trade but also to allied industries, has occupied the attention of the staff of the Institute, for already in 1913 it had become evident that "dirt" organisms were at the root of the discoloration of Stilton cheese, and later work showed that yeasts were the cause of blown condensed milk and that yeasts acting in combination with bacilli which were capable of reducing milk sugar (lactose) were the cause of fruity whey and also of one form of gassy change in Cheddar cheese.

It is important to note how these types of milk industries differ one from another.

On the one side the whole-milk trade and the condensed milk and doubtless also the dried-milk trade are all aiming to keep the milk as nearly as possible in its original state; the cheese industry on the other hand depends for success upon secondary changes which the cheese must undergo after it has been made up. This is peculiarly true in the Stilton industry.

This difference materially affects the attitude of mind of the research worker who is investigating problems with a view to advising the industry concerned. In the former case, having found the cause of the trouble, it is possible to give immediate advice and to point out that the elimination of the cause will remedy the defect. Sometimes it is not easy to discover whence the trouble comes, but having found this, its elimination ends the problem in so far as the practical man is concerned. In the latter case, however, the problem is very seriously complicated by the necessity for secondary changes which the cheese must undergo before it is ripe. If the work upon discoloration be considered, it will be seen that the probable causes of the trouble were early found, namely, "dirt" organisms, which were able to produce their effects under certain conditions. Whether, however, the use of a clean milk might not eliminate organisms which were responsible for ripening along with those which caused the discoloration, or whether indeed the organisms which caused discoloration might not themselves be the cause of ripening under different conditions were points which were not known to us. The Institute was not then and is not now in a position to state positively that the evil may be remedied by *absolute* cleanliness of the milk and sterility of the utensils, though, since the Institute obtained a farm of its own in 1920, a considerable amount of work has been carried out which clearly demonstrates that the preliminary laboratory work of previous years was sound and that the organisms which had been studied can reproduce discoloration when introduced into experimental cheeses. Moreover experimental cheeses which did ripen have been made from clean milk. But it would still be the height of unwisdom to tell the cheese maker that the remedy for such a trouble lay in absolute cleanliness of the milk and sterility of the utensils, for in an industry of this sort it may be that degrees of cleanliness are of vital importance. Is a milk containing, say, no more than 5,000 colonies, and not more than a few *B. coli* or is a milk with a bacterial content of not more than 500 and absence of *B. coli* the one that gives the best results? If the latter, then the problem will probably be easier to solve than if the former is required. For if the former is required it probably means that organisms other than those found in the starter are necessary and the nature and functions of these will need very careful investigation before anything like a complete answer can be given.

DISCOLORATION IN STILTON CHEESE.

One of the earliest investigations carried out by the staff of the National Institute for Research in Dairying was an enquiry into the cause of discoloration in Stilton cheese. A few years ago this trouble was a very grave one to the manufacturers of this particular type of cheese and resulted in very serious financial loss to some members of the industry.

Stilton is a typical unpressed blue-veined cheese, and in appearance should present a slightly creamy colour with a close network of blue veining. In the discoloured cheese, a yellow colour predominates which, later, may change to pinkish, dark brown or almost black patches which may be localized or dispersed throughout the cheese, while in very bad cases the whole cheese may present an unattractive yellowish brown appearance. There is, as a rule, nothing in the appearance of the coat of the cheese which indicates the presence of this trouble.

As the ripening of cheese is largely the result of chemical changes due to bacterial action, and as discoloration is not apparent in the earlier stages of ripening, the possibility that it was due to specific organisms was considered, and also the possible sources from which they could be derived.

The most obvious sources of contamination were the milk which was used for making the cheese, and the water supplies of the farms on which the milk was produced, and which were necessarily used for washing utensils. A large number of water and milk samples were collected from certain farms which supplied a cheese factory in which the discolored cheeses were very prevalent, and from which about 50 cheeses were received for examination.

In the preliminary investigations many hundreds of organisms were isolated from the water and milk from different farms which supplied the factory and from the cheeses which were made at this factory. These were classified by Stenhouse Williams.³

An examination of the milk supplied to the factory and of the water supplies on the farm showed the presence of harmful organisms, and a sanitary survey demonstrated that faecal contamination of the milk could readily occur and was a source of some of the organisms.

Subsequent experiments demonstrated that specific groups of these organisms were capable of acting upon definite fractions of the degradation products of casein which are formed during the ripening of Stilton cheese, with the production of a variety of colours. It was further shown that it was possible to control these colour changes to a great extent by variations in the acidity and alkalinity of the media in which the organisms were grown.

It should be emphasized that none of these organisms is present in the udder of a healthy cow; they must, therefore, be introduced into the milk during its handling. If the milk used were clean, and if these organisms were not introduced during the making of the cheese, the losses incurred from this trouble would automatically disappear with the trouble itself, but since the making of Stilton or any other cheese from bacteriologically clean milk is still only in the very early experimental stages, and the conditions necessary for its success are not yet known, it was obviously necessary to determine under what conditions in practice the discoloration arose, so that it could be avoided.

Two series of experimental cheeses have been made on the Stilton principle, but under varying conditions. In the first series (1922) the cheeses were made in batches of six. Two were made from clean raw milk, one being inoculated at the time of making with cultures of one of the types of harmful organisms and the other one remaining uninoculated as a control. The milk used for the third and fourth cheeses was clean pasteurized milk. After this had been cooled, half was inoculated with the organism and half remained uninoculated. For the fifth and sixth cheeses raw milk was used to which a small amount of tyrosine solution was added. Tyrosine is one of the degradation products of casein which is found in ripe Stilton cheese and upon which the organism under investigation is capable of producing discoloration. One half of the milk was inoculated with the organism and the other half remained uninoculated for the control cheese. In all cases a bacteriological examination of the milk was made before use, and the milk which was pasteurized was retested after cooling. Records of acidities, temperatures and details of making 54 cheeses were kept. After a suitable period the cheeses were cut and analysed, and it is satisfactory to report that more than 25 per cent. of those which had been inoculated showed definite discoloration. Although no attempt had been made to adjust the reaction of the cheese to that which experiment had shown to be favourable for the action of the organisms, yet it was found, when the acidity of watery suspensions of the cheese was determined, that the reaction was well within those limits which had been found in the earlier experiments in which the organisms had been inoculated into solutions of the degradation products of casein. These experimental cheeses showed definitely that the discolored patches were produced by the organism under investigation.

To determine whether the conditions which are unfavourable for the production of discoloration will prohibit effective blueing, and also to gain some further knowledge of the type of cheese which will be produced from bacteriologically clean milk, a second series of experimental cheeses (32 in number) have been made recently.

These cheeses have been made in batches of four under the following conditions :—(1) Clean Milk only; (2) Clean Milk + the mould which produces blueing in Stilton cheese; (3) Clean milk + the organism used in the preceding experiment; and (4) Clean milk + the organism + the mould. These cheeses have not yet been examined, but it is hoped that they will furnish useful information and that during the next and following seasons the manufacture of Stilton cheese from clean milk and from milk to which varying amounts and types of starter have been added may be carried out.

To sum up : as the result of these investigations it has been proved that the cause of discoloration in Stilton cheese is due to the presence in the milk of certain groups of organisms which act upon casein or upon certain amino acids which are formed from casein during the later stages of cheese ripening with the resultant formation of coloured substances. These organisms act most readily under alkaline conditions and are either entirely incapable of producing colours in solutions which are acid or only do so to a very slight extent.

None of the organisms which, so far, have been proved to be capable of producing colour are present in the udder of a healthy cow, and they should therefore not be present in the milk used for cheese making if this were produced and handled under bacteriologically clean conditions.

When the work was first begun the manufacturer who supplied the discoloured cheeses from which the organisms were isolated was suffering very great financial loss from this cause alone, and in view of the fact that quite early in the work the inhibitory effect of acidity was noticed, he was advised to add a little starter to his milk before making his cheese. It is generally accepted that Stilton cheese should be made from sweet milk, but, from annual reports with which he and his successor have been good enough to furnish us, the addition of starter seems to have been productive of excellent results, and since adopting the practice discoloration has been unknown in this particular factory.

Although in this case, the advice which has been given seems to have been very helpful, yet it is not known how soon conditions may arise which would be unfavourable for its continued success. It is hoped, therefore, during the coming seasons to make further series of cheeses in which the conditions for satisfactory ripening in the presence and absence of discolouring organisms may be determined, since it is not yet known whether these types of organisms or others which would be eliminated by the use of bacteriologically clean milk may not be concerned in the successful ripening of the cheese.

YEASTS IN MILK.

The possibility of loss due to yeasts has not generally been very well recognised by the milk and dairy industry, yet there can be very little doubt that they may be a grave source of loss, certainly to the sweetened condensed milk industry, and possibly to others—a loss which could be practically eliminated if a better understanding of the methods of handling milk existed, not only at the farm but also at the factory.

The best known action of the yeasts is the alcoholic fermentation of sugar, in which the sugar is converted into carbonic acid gas and alcohol with various acids, aldehydes and esters as secondary products. The defects in milk products due to the presence of yeasts, will, therefore, be mainly those caused by the production of gas, or the development of taints. Both types have been under investigation in the laboratory.

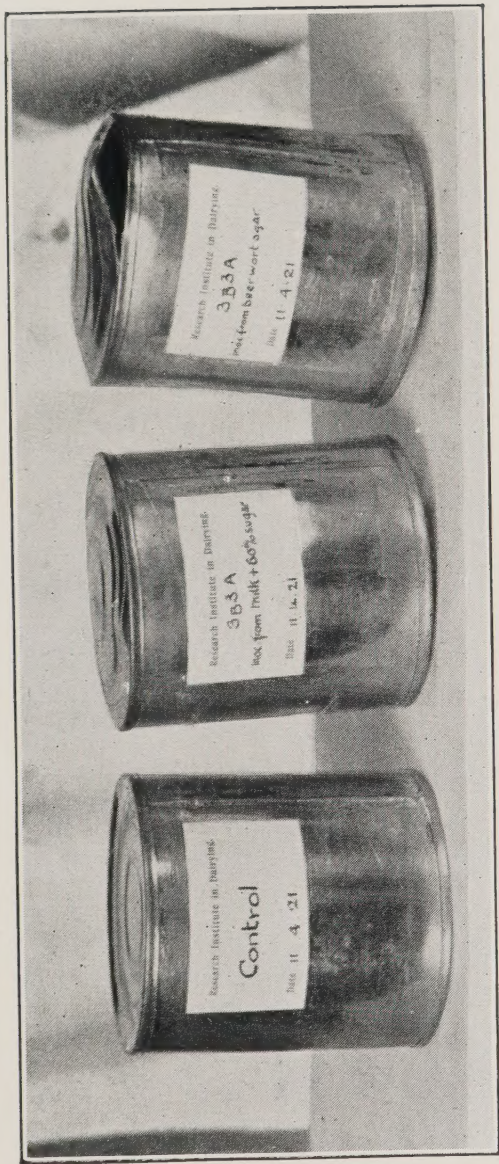
The saccharose-fermenting yeasts are numerous, and are of considerable interest since they may be a source of serious loss to the manufacturer of milk products to which cane sugar is added, such as sweetened condensed milk. The growth of many of these yeasts is inhibited by the high percentage of cane sugar used as a preservative, but the presence in the tins of those which are able to ferment saccharose even in high concentrations may result in the setting up of alcoholic fermentation with consequent “blowing” of the tins due to the pressure of the gas thus generated.

Two types of yeast have been isolated at the Institute,⁸ from blown tins of sweetened condensed milk. Both of these types were proved to be capable of reproducing blowing in sound tins of milk.

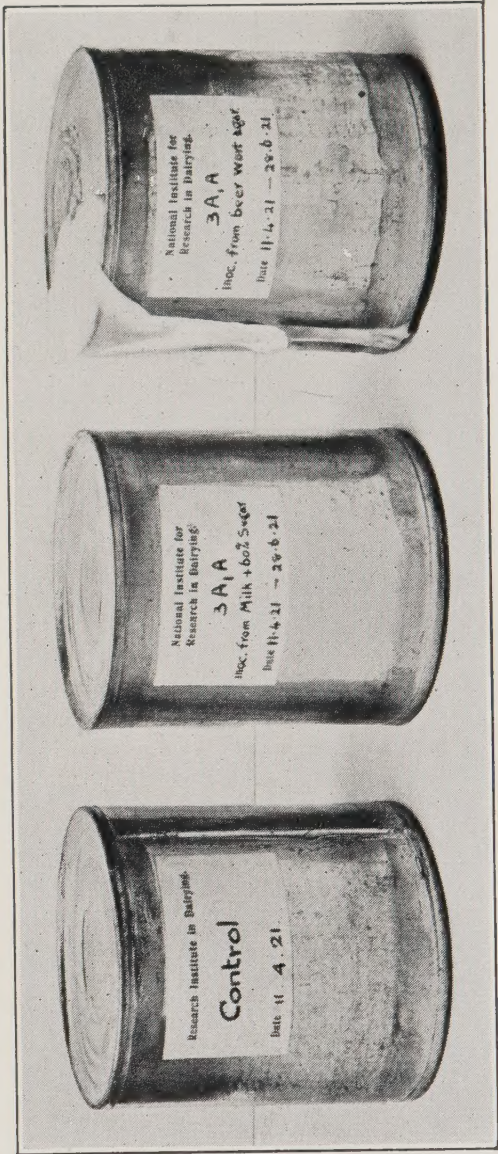
They were both unable to ferment lactose, but readily fermented glucose, laevulose, and saccharose, the last even in concentrations of 70 per cent. In neither case has it been found possible to induce spore-production.

One type consisted of small oval cells. It was very rapid and vigorous in its action upon saccharose solutions, but was only slightly resistant to drying and to temperatures from 65° C. to 70° C.

The other type consisted of somewhat larger round cells. It was less rapid and vigorous in its action on saccharose, but more resistant to heat and drying, having been found to survive heating in milk to a temperature of 73° C., and on one occasion even 83° C. The results of a series of determinations of the thermal death point of this yeast illustrate the fact that its resistance to heat is greater in milk than in such a liquid as 50 per cent. cane sugar syrup.



OVAL YEAST—AFTER 17 DAYS.



ROUND YEAST.

TABLE XV.

Thermal Death Point of Round Yeast.

Culture from which cells were taken.	Emulsion.	Number of heated cells introduced into each tube tested.	Temperatures to which cells were heated. °C.					
			Un-heated	55	65	73	85	100
Culture on B.W.A. -	Milk	600,000	+	+		+	-	-
2 days at 22°C. -	Syrup	600,000	+	+		-	-	-
Culture on B.W.A. -	Milk	800,000	+	+		+	+	-
9 weeks at 22°C. -	Syrup	800,000	+	+		-	-	-
Culture on B.W.A. -	Milk	5,400,000	+	+		+	-	-
2 days at 22°C. -	Syrup	5,400,000	+	+		-	-	-
Culture on B.W.A. -	Milk	12,500,000	+	+		-	-	-
2 days at 22°C. -								
19 weeks at R.T. -	Syrup	12,500,000	+	+		-	-	-
Culture on B.W.A. -	Milk	?	+	+	+	+	-	-
4 days at 22°C. -	Syrup	2,970,000	+	+	-	-	-	-
7 days at 37°C. -								
Culture on N.A. + 60%								
4 days at 22°C. -	Syrup	2,100,000	+	+	+	-	-	-
7 days at 37°C. -								
Cells on Sugar.								
3 weeks at 30°C. -	Syrup	520,000	+	+	-	-	-	-
7 weeks at R.T. -								

+ = Presence of living cells (-) = Living cells not found. B.W.A. = Beer Wort Agar. N.A. + 60% = Nutrient Agar + 60% Cane Sugar. R.T. = Room Temperature.

It is important to note the difficulty that may be experienced in eliminating this yeast once it has gained a foothold in the factory, since it may survive the temperature of pasteurisation. Further, since its action is somewhat delayed, its presence in the tins may not be detected before the tins have left the factory and are on the market.

Statistics of the loss to the condensed milk factories, resulting from this cause alone, are not available, but such loss must be considerable. This trouble is not confined to one area, but seems to be widespread, since similar organisms have been isolated by Pethybridge³⁵ from Irish sweetened condensed milk, by Hammar³⁶ from American sweetened condensed milk, and by Knudsen³⁷ from Danish and Dutch sweetened condensed milk. In each case they have been demonstrated to be the cause of the "blowing" of the tins.

YEASTS IN CHEESE.

Whilst the yeasts which ferment glucose but not lactose do not of themselves play an important rôle in the dairy industry, they may, under certain conditions, assume considerable importance. They are widespread and of common occurrence, and may therefore easily gain access to the milk. They will usually multiply in milk though without causing fermentation, but, in the presence of other organisms which are able to hydrolyze the lactose to glucose and galactose, a vigorous fermentation may be set up with the production of gas and characteristic odours and flavours. Such a fermentation has been investigated in the laboratory (unpublished M.Sc. Thesis). A sample was taken at the Dairy Show of 1920, from vats in which a marked fruitiness was noticed during the making of the cheese. Information was later received that a similar trouble periodically occurred in other parts of the country.

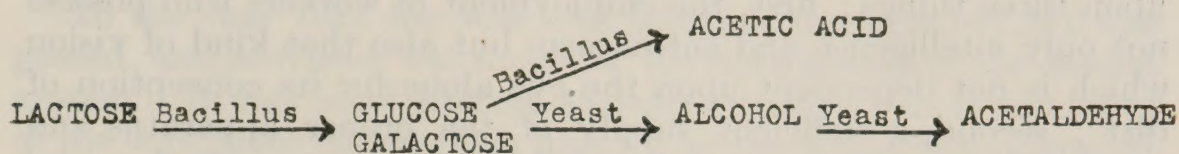
From the whey a yeast was isolated which was suspected of being the cause of the trouble. On inoculation into milk, however, no apparent action resulted. There was no fermentation and no trace of the odour sought could be detected.

A quantity of the original whey was still available. From this whey tubes of sterile separated milk were inoculated and incubated at 22° C., 30° C. and 37° C. Coagulation occurred in all the tubes, but only those incubated at 37° C. gave the fruity odour. A microscopical examination of these tubes showed the presence of yeasts and a few cocci, but long bacilli (or chains of short rods) were dominant. In the tubes kept at the lower temperatures cocci were dominant. These organisms were isolated and inoculated into milk, but none of them was able to reproduce the fruity odour. This was accomplished only when the yeast and the bacillus were both present in the milk. A study of the characters of the bacterium showed that in most respects it closely resembled *B. bulgaricus* but differed from it in that its optimum and maximum temperatures were slightly lower. The yeast closely resembled those used in the manufacture of wines and beers. It readily fermented glucose, galactose and saccharose but not lactose.

The production of the fruity odour was, therefore, due to the combined action of the bacillus and the yeast. Since the yeast was unable to ferment lactose, but readily fermented milk in which the bacillus was growing, the probability was that the bacillus converted the lactose into sugars such as glucose and galactose, which were fermentable by the yeast.

Chemical analyses of milk cultures of bacillus, yeast and a mixture of bacillus and yeast demonstrated that the bacillus converted the lactose into simpler sugars, such as glucose and galactose, and that the yeast, acting on these products brought

about alcoholic fermentation. The fruity odour was due to alcohol and acetaldehyde (produced by the oxidation of the alcohol by the yeast) together with acetic acid produced by the action of the bacillus.



That the production of the fruity odour depended upon the type of bacterium was demonstrated by growing the yeast in milk in combination with two strains of starter bacteria, and with a strain of *B. coli*. In each case acidity was produced but no trace of the fruity odour could be detected. It is known that glucose and galactose can rarely be detected in milk cultures of ordinary starter bacteria, so that, in the absence of fermentable sugars, the yeast would be unable to act. On the other hand, in combination with cultures of *B. bulgaricus* which are known to bring about hydrolysis of the lactose, the yeast readily produced the fruity odour.

In order to complete the work it was obviously necessary to demonstrate practically that the combination of the yeast and bacterium isolated would produce "fruitiness" during the process of cheese making. It was not possible to undertake this work till 1923, although the isolation of the original strains took place in 1921. In the meantime the strain of the bacillus had lost much of its potency. For the present, therefore, cheeses have been made with an active strain of *B. bulgaricus*, which the isolated organism closely resembles, acting in conjunction with the yeast. Clean milk was used and all the utensils were carefully sterilized. The culture of *B. bulgaricus* was used as a starter, and the yeast was added to the milk as soon as it was placed in the vat. During the process of making, a definite fruity odour could be detected in the vats, and later also in the cheese, in which alcohol could be demonstrated. Control cheeses made with the same milk, but without the addition of yeast, and with the same cultures of *B. bulgaricus* as starter, developed no fruitiness. Fruitiness was also absent from cheese made with milk to which the yeast had been added but in which an ordinary dairy starter had been used.

It is, of course, true that yeasts may cause other defects in milk products, but since they have not, up to the present, been investigated at the Institute, they are not mentioned here. The work which has been set forth clearly shows the importance of an accurate knowledge of the methods of the handling of milk, since all the faults that have been discussed have been due to the admission of extraneous matter into milk after it has left the cow.

COLLATERAL EVENTS.

The work which has been carried out at the Institute has demonstrated that success in the production of clean milk depends upon three things; first, the employment of workers who possess not only intelligence and enthusiasm but also that kind of vision which is not dependent upon the eye alone for its conception of dirt; second, a sufficient supply of the proper apparatus and reasonable conditions of work; and third, an adequate financial return for the extra and more intelligent labour involved. The great importance of the first of these factors was brought home to us when we began this work in November 1916. Three dairy farmers expressed the wish that regular bacteriological examinations of their milk should be made at the Institute. On one of these farms no proper provision had been made for the production of clean milk and the sample soon ceased to come. On the second considerable sums of money had been expended in providing a milking shed of the most approved type and all the apparatus necessary for the production of clean milk, yet the samples which were sent to the laboratory for examination were rarely up to standard, and when visits were paid to the farm at milking time grave errors in the methods of production could always be demonstrated. Eventually the samples of milk ceased to be sent. It is true that the owners of this farm started this work under conditions made difficult by the war, but it is equally true that at no time was the work under the control of a person with the right kind of vision and sufficient enthusiasm to inspire those who were responsible for the carrying out of the details.* If clean milk production is to become at all general in this country it is necessary that a greater number of persons than exist at the present time shall be trained in the technical details of the work. That this object might be attained a variety of different steps have been taken.

In the year 1916 the dairy teachers were gathered together by the Agricultural Education Association and plans were considered for modifying dairy teaching in our schools so as to include, amongst other changes in the methods of education, further instruction in the production and handling of milk. The progress of these schemes was promoted by the British Dairy Farmers' Association, which called a meeting of educational authorities in the autumn of 1921. As the result of that meeting a special committee representing most of those bodies which grant Diplomas in Dairying was formed. It was no easy task which that Committee undertook, but at the end of nearly two years, a scheme has been prepared and is now being submitted for the consideration of the various bodies which were represented.

* Since these words were written in 1919 "the person with the right kind of vision" has been found, and this farm has now (1923) been producing milk of a high standard of cleanliness for some years.

During the war the Ministry of Food, acting in collaboration with the Ministries of Health and Agriculture, first granted licences for the sale of a cleaner milk and permitted an extra charge to be made. The official recognition of the fact that such milk had an increased monetary value was a great stimulus to progress.

In the year 1922 the Milk and Dairies (Amendment) Act was passed, and provision was made for the continuance of the graded system. It may be of interest, therefore, to give a short summary of the conditions under which licences for the production of graded milk are granted.

Certified milk is milk which is produced from herds which do not react to the tuberculin test; it must be bottled on the farm, sold in the raw state, and must not contain more than 30,000 bacteria per 1 c.c. or show the presence of *B. coli* in 1/10 c.c. on delivery to the consumer. Licences for its production may be obtained from the Milk Section of the Ministry of Health, Whitehall, London, S.W.1.

Grade "A" (Tuberculin Tested) milk is also produced from cows which do not react to the tuberculin test and is sold in the raw state. It differs from Certified milk in that it may be sent by rail in sealed churns to be bottled at the dealer's premises. It must not contain more than 200,000 bacteria per 1 c.c. or *B. coli* in 1/100 c.c. on delivery to the consumer. A licence for its production is obtainable from the Ministry of Health.

Grade "A" milk is produced from cows which are subject to veterinary inspection; it may be sent by rail in sealed vessels to be bottled at the dealer's premises and may be sold either in the raw state as Grade "A" milk or, after pasteurizing, as Grade "A" milk (Pasteurized). If it is sold in the raw state then it must not contain more than 200,000 bacteria per 1 c.c. or show the presence of *B. coli* in 1/100 c.c. on delivery to the consumer. If it is sold as Grade "A" milk (Pasteurized), then it must be retained at a temperature of not less than 145° F. and not more than 150° F. for at least 30 minutes, and must then be immediately cooled to a temperature of not more than 55° F. Such milk must not contain more than 30,000 bacteria per 1 c.c. and *B. coli* must be absent from 1/100 c.c. on delivery to the consumer. Licences for the production of this milk can be obtained from the Local Authority.

It is to be noted that this Act leaves the milk industry free to handle Certified, or Grade "A" (Tuberculin Tested) or Grade "A" or Pasteurised Milk or to go on in the old way. The old way is certainly disappearing and cannot last, but had the regulations been made compulsory throughout the country, there was no machinery which could have made it a success. There were not then and there are not now anything like a sufficient number of people with the requisite training to meet such a situation. As it is, it has been the more eager and keen members of the industry who have taken up these licences, and very serious efforts have been made by the Ministry of Agriculture and

the Dairy Schools to render all the assistance that they possibly could. This co-operation between Agriculture and Public Health is a very live thing nowadays and is one of the most hopeful assets for the future of milk in this country. Certainly those who work at the National Institute for Research in Dairying appreciate it very much when they find that they have the support of the Ministry of Health and are appealed to by many Medical Officers of Health, and at the same time receive a request from the Ministry of Agriculture to allow a number of the Ministry's Inspectors to spend a week working with the staff of the Institute.

The Ministry of Agriculture has done much to promote this work. Under its auspices special courses for dairy teachers have been held at the Institute in each of the years 1917, 1919, 1921, 1922, and 1923. In addition to these special courses, a number of individuals have spent varying periods of time at the Institute that they might carry out similar work.

In the year 1920 the staff of the Institute first gave a clean milk demonstration at the Oxfordshire Show. In those days, and it is only three years ago, their demonstration inspired a certain spirit of levity. In the year 1923 it has been a matter of the greatest difficulty to meet the requests which have been made either to carry out such demonstrations or to assist those who wished to undertake them. A very notable demonstration was given at the Bath and West Show at Swansea to which ten different authorities contributed, and the demonstration at Newcastle under the auspices of the Royal Agricultural Society of England met with no mean success.

Mr. Hatfield of the Ministry of Agriculture has done some valuable work in this cause, and has during 1923 succeeded in holding these demonstrations at nearly every Welsh show in addition to some in England.

The total number of demonstrations which have received assistance of one sort or another from the Institute during 1923 amounted to twenty-seven.

In 1920 a Clean Milk Competition was started in Essex. In 1921 such competitions were held in Essex and Sussex. In 1922 they were found in Essex, Sussex, Hampshire, Bucks and at Blackburn and in connection with the Bath and West Show.

These represent some of the activities which are going on, but through it all there remains the simple fact that sufficient provision has not yet been made for rendering assistance to those who are anxious to take up the production and distribution of Grade "A" (Tuberculin Tested), Grade "A," Certified, or Pasteurized Milk. The words which were written in May 1922 in the *Dairyman*¹¹ (Stenhouse Williams & Mattick), are still true: "That the proposed measure may be made more effective it should be supported by educational facilities." It should be made possible for the Agricultural Colleges to assist all those in their districts who are anxious to take up Grade "A" or Grade "A" (Certified) milk production and distribution. Such assistance consists in the

regular examination of samples of milk and willingness to visit the farm or other premises, spending such time as may be necessary and working alongside and in friendly relationship with those who are actually responsible. An illustrative case may make the value of the work clear. A Grade "A" milk producer was not satisfied with his results. A member of the staff of the National Institute for Research in Dairying went down to the farm. He spent three days there, assisted at the milking, morning and afternoon, helped in the washing up and the steaming of utensils, showed the workers where errors were creeping in and laid down simple rules to guide their future work. In the evenings he explained to the farm hands the work that was done at the laboratory so that they would have some conception of the meaning of the reports on their milk which are sent to them regularly. As a fact the cleanliness of the milk from that farm has been revolutionised. Such work is continuously going on, and it is only by its continuance and spread that the necessary atmosphere of knowledge can be diffused throughout the industry. The present staff and income of the National Institute for Research in Dairying are far too small to deal with the need of the whole country.

It appears that the wisest procedure at the present time is to follow up what has been begun by providing funds to the Agricultural Colleges for the promotion of work similar to that which is being done at the National Institute for Research in Dairying.

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